AN EXPERIMENTAL APPROACH TO THE STUDY OF BIRD POPULATIONS

BY V. E. SHELFORD

THAT the size of bird populations is a matter of interest to ornithologists is evidenced by the publication of *Audubon Field Notes* showing bird counts of various kinds conducted at regular intervals. It is especially praiseworthy that these counts are made of all birds regardless of their value as game or their value or detriment to agriculture. The use that has been made of the counts pays tribute to the efforts of non-professional scientists.

The size of bird (or other animal) populations is the result of the interplay of several factors, but it seems evident that an increase in the number of eggs produced and superior vigor of the young can outweigh normal predation and minor disasters. The simplest cases for testing this statement are those showing the operation of these potent factors during *critical* periods in the annual physiological cycle of the bird. One of these critical periods, which is probably related to the size of the clutch, is the late, rapid development period of the gonads.

What factor acting at this gonadal development period could influence the size of the clutch and the vigor of the young birds? In the case of an insect, a grouse locust (*Acrydium arenesum angustum*), ultraviolet light induces accelerated reproduction (*i.e.*, more offspring) with greater vigor than ordinary "white" light. Without continuous ultraviolet light stimulus over two or more months, this species would not breed in the green house where the work by Sabrosky, Larson, and Nabours (1933) was done. Under somewhat similar circumstances a pair of monkeys was induced to breed in a London zoo by the application of ultraviolet light (Stetson, 1947:181).

Marshall and Bowden (1934:418) greatly shortened the period to oestrous in a ferret by the application of carefully measured ultraviolet light. Oestrous in mammals is the equivalent of egg laying in birds, and since Bailey (1950) announced that ultraviolet light increases egg production by poultry, it seems logical that ultraviolet light may also affect the reproductive rate of other birds as well.

Other factors also may influence the size of clutch. Yeatter (personal communication) states that in the pheasant (*Phasianus colchicus*) clutch size appears to be related to temperature. In work with fish, Merriman and Schedl (1941) found that both strong light and high temperature are necessary for the development of reproductive cells of the four-spined stickleback (*Apeltes quadracus*).

Kendeigh (1944:82) utilized the Christmas bird counts for the state of Ohio to estimate the populations of quail (*Colinus virginianus*) in the entire state (1908 through 1942). This writer published a curve (Shelford, 1951: 169) showing the intensity of solar ultraviolet for the month of April, 1924–1938, as measured over that period on Mt. Wilson, California by Pettit (International Astronomical Union). When this is drawn parallel to Kendeigh's population curve from 1925 through 1938, it is evident that there is a narrow band of solar ultraviolet which appears to be an optimal range. When intensities were either above or below the apparent optimum range, populations declined. In all years in which April solar ultraviolet was within the optimal limits (102 and 117) there were increases over the quail count of the preceding year. Other studies show (Shelford, 1951:170–173) that moisture also influences quail population, though ultraviolet is most important. Usually two or more factors predominate in controlling fecundity and other physiological processes. Each of us has noted the combined action of temperature and moisture in affecting our sensations on hot, moist and hot, dry days at similar temperatures (Shelford, 1952b:155).

Considerable scientific work on fecundity control of the domestic fowl has been done. Whetham (1933:398) found there were optima of amount of light in connection with activity and suggested that the same principle applied to reproduction. She stated further that light stimulates the production of an internal secretion (anterior pituitary) which activates the ovary (1933:395). She stated that larger consumption of food in the case of birds given additional hours of light is due to the increased egg production induced by more light. Nutrition available is diverted to egg production rather than to the accumulation of fat. She did not suggest that the supply of foods plays no part in the production of eggs, but rather that factors such as deficiency of internal secretion limit the production. When a large supply of the internal secretion is present, egg production may continue for some time in the absence of adequate food supplies at the expense of body weight. A practical example of this was given by Hansson (1930:199) who showed that in one case increased illumination alone, without improvement of an unbalanced ration, resulted in an increase of egg production from 20 to 40 per cent (over controls).

In Fig. 1 the number of pheasant nests per 100 acres in northwest Ohio is shown for the year following the occurrence of the amounts of sunshine (in percentage of the total possible) and rainfall (in inches) indicated for April of the preceding year. This is because young pheasants make nests the year following hatching. Studies of paired factors have led to the drawing of this type of diagram. The drawing of the base of such a diagram is very simple. The intensities of the two factors are scaled on two sides of a rectangle such as Fig. 1. The conditions in a period such as a month, *e.g.*, April, are chosen for study here because of the general knowledge of the reproduction of birds.

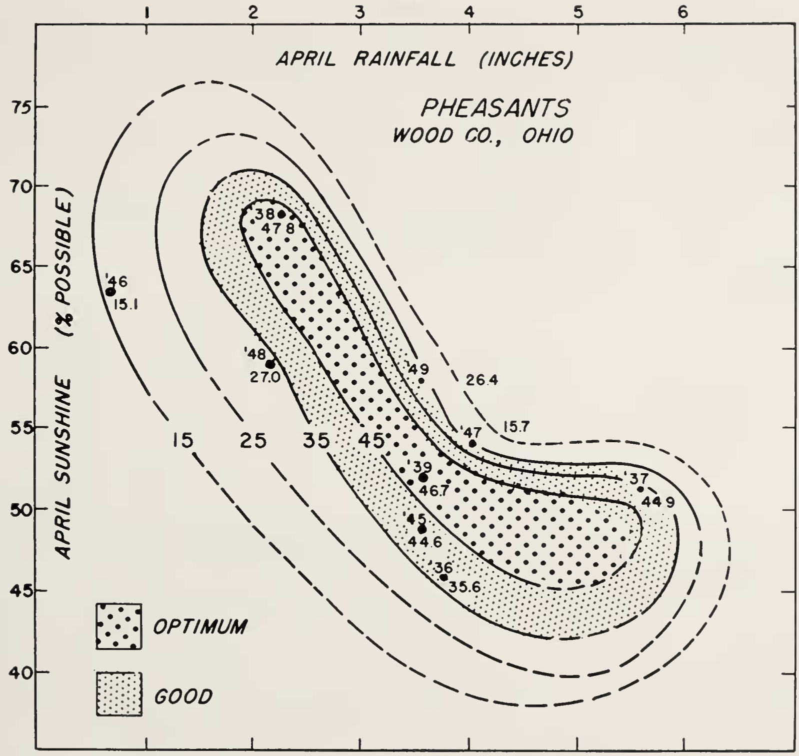

FIG. 1—A heliohydrogram, showing the number of pheasant nests per 100 acres as recorded in northwestern Ohio the year following the one plotted. The numbers are plotted at the intersections of coordinates representing the amount of sunshine in April in percentage of the total possible (recorded at Fort Wayne, Indiana) and rainfall in April (recorded at Bowling Green, Ohio). The interaction of these factors appears to have had an important influence on the size of population. Although for best results these records should have been made in the study area, it is suggested that the same approximate number of nests occurs in series of different combinations of rainfall and sunshine; for example, approximately 47 nests per 100 acres fell on approximately 68 per cent sunshine and 2.25 inches of rain and also on 53 per cent sunshine and 3.5 inches of rain; the data are too few but the ellipses shown follow the general pattern of such relationships. Optimum conditions, based on the largest number of nests, are in the center. The stippled areas indicate two zones of favorability in conditions, and the lines connect years of approximately equal population. Data are from E. Dustman's release No. 203 (1950) of the Ohio Wildlife Research Unit, Ohio State University.

The coordinate points for the two factors are located: for example the 1946 April sunshine was near 63 per cent of the total possible and the rainfall less than an inch. When the coordinated points are all located, the population data are written adjacent to them. The pattern is studied and, if possible, lines con-

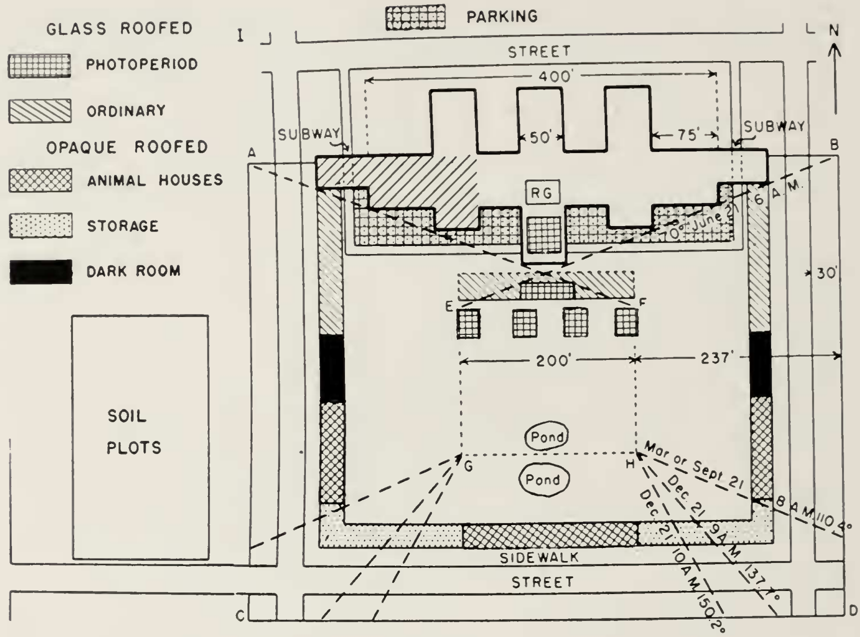

Fig. 2—"Life science" building with a yard at its south enclosed by essential one-story buildings. Area E-F-G-H, a little less than 200 feet square, at 40° N. Lat. has no shadows from 6 a.m. to 6 p.m. when objects 70 feet high are at least 237 feet from its east or west border and a lesser distance from its south border. The dark rooms are for photo-period work. The four small glass-roofed greenhouses are provided without shadow from each other to permit the use of colored glass. The heavy line surrounds the main building which is of interest only in that it casts no shadows on the well lighted area, and supports a roof garden (RG). This is an improvement over the unenclosed plan (Shelford, 1952a). The angles of the sun at various times are shown in the figure, at the right. The corresponding angles for the afternoon are at the left.

necting equal populations are drawn. In this case the figure is good and the apparent discrepancy of 1937 could easily result from a heavier *local* rainfall at the weather station used.

Birds seem to be the ideal vertebrate material for the study of relations of physical factors to fecundity and vigor of offspring. There are good series of domesticated and semi-domesticated species available for study and development of methods which may later be applied to wild species. The size of the clutch is evident in a short time while in the case of mammals there is a long period of gestation.

To be fully valid the final checking of the results of field study, diagrams, etc. should be done out of doors. This raises the question of the requirements of a suitable workshop. Experimental work which involves simulation of natural conditions and the use of variable as well as constant conditions requires the use of out-of-door facilities. Length-of-day effect can be studied by following the practice of some plant laboratories which bring plants from dark rooms into sunlight each day for any period of time desired.

On grounds adjacent to laboratories with dark rooms birds may be subjected to small additions of short or long wave radiation, semi-out-of-doors studies of metabolism may be conducted, and small birds may be trapped under permit. The area for this purpose must be completely enclosed, and essential and useful buildings may best be used to enclose the area (Fig. 2).

Experimental studies call for electrical service, and the use of delicate instruments which cannot be operated away from a laboratory. Birds have been used for considerable basic study in spite of the serious handicaps which have attended some research. With better facilities much more can be done.

The plant shown in Fig. 2 is designed for the biological work of a rather large institution. Because of the unusually favorable character of birds as material for the study of the physiology of reproduction, ornithologists can exert considerable influence toward securing better conditions for experimental work with them, or still better, interest someone in providing the funds to build suitable facilities. Most institutions are not equipped for research such as is needed.

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UNIVERSITY OF ILLINOIS, VIVARIUM BUILDING, WRIGHT AND HEALEY STREETS, CHAMPAIGN, ILLINOIS, AUGUST 15, 1954